ORBITAL/SUB-ORBITAL PROGRAM 2 (OSP2)

ATTACHMENT 2.C

TECHNICAL REQUIREMENTS DOCUMENT

MINUTEMAN-CLASS

SPACE LAUNCH VEHICLE CONFIGURATION

(MMSLV)

DRAFT 1

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RFP XXXXXXX

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1.0 SCOPE

1.1 Objective

The Government's objective is to utilize excess Minuteman (MM) assets to provide a launch capability to place small satellites into orbit. To support this objective, Minuteman II assets, including motors and interstages, will be made available as GFP.

1.2 Overview

This document defines performance requirements for a Minuteman class Space Launch Vehicle for placing small spacecraft into orbit. Sample mission orbits are defined for the purpose of establishing the throw-weight requirements. A high inclination orbit and a low inclination orbit are specified reflecting the Governments desire to have a flexible launch vehicle capable of meeting a variety of payload and orbit requirements. Payload definition and detailed mission requirements will be provided in a Mission Requirements Document (MRD) issued by the Government at the time authorization to proceed is given for each delivery order.

Technical requirements for several "enhanced capability" options are defined in the Appendix to provide additional capabilities. These correlate to CLINS identified in Section __. The Launch Vehicle shall meet these requirements for those missions on which the applicable CLIN is exercised.

2.0 APPLICABLE DOCUMENTS

2.1 Compliance Documents

The documents listed below shall be complied with to the extent specified in the column entitled "Tailored Application":

Number/Date	Title	Tailored Application
2.1.1 ER/WR 127- 1 31 Oct 1997 Change Pages 23 Oct 2000	Eastern and Western Range, Range Safety Requirements	As Tailored with Range Safety approval
2.1.2 IRIG Standard 106-96	Telemetry Standards	

3.0 REQUIREMENTS

3.1 System Description

The OSP-2 MM based Space Launch System consists of the Launch Vehicle (LV) and the Ground Segment.

3.1.1 Launch Vehicle

The Government will provide Minuteman II motors, interstages, and associated equipment as GFP. The motors and interstages will be assembled into a multi-stage booster, certified for flight, and be delivered to the launch site by the Government.

The Contractor shall provide hardware and software to accomplish the following functions:

- Payload interface
- Guidance and control
- Instrumentation and telemetered data
- Airborne range safety functions
- Attitude control after final stage burn out.
- Additional propulsion capability as required

3.1.2 Ground Segment

The Ground Segment shall consist of:

- Contractor furnished Support Equipment consisting of all equipment required to process, integrate, checkout, and launch the LV.

- Minuteman ground support equipment and handling equipment provided GFP as available. This includes a modified MM Transporter/Erector for break over of the MM motor stack to support above ground launches.

- Launch Facilities furnished by the Government. Modifications, if necessary, shall be furnished by the Contractor.

- Optional contractor provided booster and CFE front end environmental protection system for sites without environmental protection. (Option A-9, Appendix A)

3.2 Characteristics

3.2.1 Performance

3.2.1.1 Throw-weight to Orbit

The Launch System shall be capable of placing spacecraft into a variety of orbital inclinations, eccentricities, and altitudes. The two sample missions below define specific throw-weight requirements.

Orbit A

Inclination:	sun synchronous
Altitude:	400 nmi X 400 nmi
Throw-weight:	700 lbs minimum

Orbit B

Inclination:	28.5 deg
Altitude:	100 nmi X 100 nmi
Throw-weight:	1300 lbs minimum

Sufficient performance margins shall be included to provide a .997 (3-sigma) probability of achieving the required orbit when all potential sources of dispersions are accounted for. The LV shall provide the capability of accommodating lower payload weights.

3.2.1.2 Insertion Accuracy (3-sigma)

Maximum dispersions of the payload orbit after deployment for Orbit A and the specified payload weights shall be within $\pm$10 nmi altitude for insertion apse, $\pm$35 nmi non-insertion apse, and $\pm$0.2 deg inclination. (See Appendix A for enhanced capability option).

3.2.1.3 Attitude Control (3-sigma)

The Launch Vehicle shall control its attitude at the time of payload deployments to $\pm$ 1 degree of the desired attitude with drift rates less than 1-deg/sec. Tip-off rates of the payload shall be limited to 5 deg/sec.

3.2.1.4 Collision/Contamination Avoidance Maneuver

The Launch Vehicle shall provide the capability of performing a collision avoidance maneuver to minimize payload contamination and preclude recontact between the deployed payloads and the launch vehicle.

3.2.2 Payload Requirements

The Launch System shall be designed to accommodate a variety of payload sizes, shapes and interfaces. The payload may consist of a single spacecraft or multiple spacecraft. Additional hardware required to accommodate multiple payloads will be the responsibility of the government.

3.2.2.1 Mechanical

3.2.2.1.1 Envelope

The Launch Vehicle shall provide a fairing that accommodates a cylindrical payload envelope 40 inches in diameter and 60 inches long. (See Appendix A for enhanced capability option).

3.2.2.1.2 Access

The Launch System shall provide access to the payload after fairing mate without removing the fairing or breaking electrical connections. The minimum opening size shall be 100 square inches. Access size and location shall be defined in the ICD. (See Appendix A for enhanced capability option).

3.2.2.1.3 Interface

The Launch System shall provide a non-separating structural interface on which to mount the payload assembly. (See Appendix for enhanced capability option).

3.2.2.1.4 Mass Properties

The Launch System shall accommodate payload weights up 1500 lbs with a center-of-gravity up to 30” forward of the interface and a lateral offset of up to 1 inch.

3.2.2.1.5 Structural Characteristics

The Launch System shall accommodate payloads with a first mode natural frequency of at least 11 Hz.

3.2.2.2 Electrical

3.2.2.2.1 Ordnance Discretes

The Launch System shall provide the following capabilities based on 1.5 ohm payload loads:

Quantity:	Up to 16 circuits
Minimum current:	5 amps
Timing accuracy:	10 millisec
Minimum Duration:	35 millisec
Simultaneity:	Up to 8 discretes with a tolerance of 1 millisec

The circuits shall also be capable of providing 28 volts $\pm$ 4 volts to a high impedance load.

3.2.2.2.2 Telemetry

The Launch System shall provide a bit rate of at least 16 Kbps for payload use with flexibility to support a variety of channel/bit rate requirements, and provide signal conditioning, PCM formatting (programmable), and data transmission. Up to 24 channels shall be provided. The number of channels, sample rates, etc will be defined in the Mission Requirements Document. (See Appendix for enhanced capability option).

3.2.2.2.3 Command, Control, and Monitor

The Launch System shall provide up to 24 umbilical circuits to the payload until launch. The circuits shall include ground power conditioned to 28$\pm$4 Vdc and current limited to 5 amperes.

3.2.2.3 Environments

The Launch System shall provide payload flight environments not to exceed the following:

Acoustic	TBS
Shock	TBS
Vibration	TBS

Transient loads	TBS
Steady state acceleration	TBS

3.2.2.3.1 Thermal

The Launch System shall provide aerothermal protection to the payload prior to launch and during ascent. The internal wall temperature of the fairing shall be limited to 200 deg F in the cylindrical portion during ascent. The fairing shall be retained until aeroheating rates are below 0.1 BTU/sq-ft/sec. During ground processing prior to launch, the spacecraft temperature shall be maintained within 60 to 120 deg F neglecting internal heating sources from the payload. Provisions shall be made to facilitate the implementation of conditioned air if required. (See Appendix for enhanced capability option).

3.2.2.3.2 Contamination

The Launch System shall maintain the payload in a Class 100,000 environment at all times with no condensation forming on payload surfaces. Inner surfaces of the fairing and payload deck shall be cleaned so that they are Visibly Clean, Level II. Provisions shall be made to facilitate the implementation of a continuous clean dry nitrogen purge. (See Appendix for enhanced capability option).

3.2.2.3.3 Plume Effects

The launch Vehicle shall minimize plume effects from all propulsion sources in terms of forces applied to the spacecraft after deployment and contamination prior to and after deployment.

3.2.3 Telemetry and Instrumentation

The Launch System shall collect and transmit sufficient data during pre-launch and in-flight to assess status, performance, and environments; to meet all Range Safety requirements per Reference 2.1.1; and to provide diagnostics in the event of anomalous performance.

3.2.3.1 Navigation Data

The Launch System shall provide navigation data in accordance with Paragraph 2.1.1 requirements.

3.2.3.2 Telemetry Characteristics

The Launch System shall provide pulse code modulation (PCM) telemetry in accordance with Paragraph 2.1.2. It shall provide a total bit rate of at least 750 Kbps. (See Appendix for enhanced capability option). The telemetry system shall use and provide flexibility in allocating channel bandwidths. It shall include the capability of storing and delaying transmission of telemetry data if required due to availability and location of receiving stations.

3.2.3.3 Transmitter and Antenna Characteristics

Signal-to-noise margins over 95% of the radiation sphere shall be adequate to achieve a bit error rate no greater than 10^{-6} when transmitting 2100 nmi to a ground station antenna with a gain (G/T) of 15 dB/^{o}K.

3.2.4 Airborne Range Safety Requirements

The Launch System shall include a command destruct system, radar aiding transponder, GPS range safety tracking, and any hardware and/or modifications required for compliance with the applicable portions of Reference 2.1.1. Minuteman downstage instrumentation and ordnance will be provided and installed as GFP if desired by the Contractor.

3.2.5 EMI/EMC

3.2.5.1 Emissions

The Launch System shall minimize radiated and conducted emissions that could affect the payload. Specific levels are TBS by the Contractor.

3.2.5.2 Susceptibility

The Launch System shall be capable of operating at any of the identified launch sites without adverse effects from the electromagnetic environments. The Launch System shall also be capable of withstanding EMI radiated and conducted emissions from the payloads. Specific limitations imposed on the payloads are TBS by the Contractor.

3.2.6 Launch Availability

The vehicle shall be capable of launching under 90 percentile (annual) wind conditions from VAFB. All other limitations (excluding weather) shall not preclude launching for more than one hour per 24 hour period.

3.2.7 Mission Reliability

The Launch System shall have a design reliability (excluding GFP motors and interstages) of meeting all mission requirements greater than 98 percent. Equipment associated with Range Safety shall meet reliability requirements of Paragraph 2.1.1.

4.0 QUALITY ASSURANCE

4.1 Verification

A verification program shall be conducted to ensure compliance with section 3 of this document and with the specifications developed by the Contractor. Verification shall be demonstrated through test, analysis, similarity, demonstration, or inspection.

4.2 Development Tests

A development test program shall be conducted to determine flight environments, reduce risks associated with qualifying components to new environments, quantify structural characteristics, demonstrate structural capabilities and mechanical assemblies, and assess interface compatibility among subsystems. The test program shall be structured to account for previously demonstrated flight proven capabilities.

4.3 Qualification Tests

Components shall be qualified (through test or similarity) to show adequate design margins exist over Maximum Predicted Flight (MPF) environments. Dedicated (non-flight) components shall be used for qualification testing in the case of non-developmental items unless waived by the Government. Software shall be subjected to a qualification test program to demonstrate compliance with requirements and robustness in off-nominal situations.

4.4 System Integration Test

A system integration test shall be performed with a goal of demonstrating all procedures, verifying SE, LV, booster, payload, and facility interfaces. The nature of the test in terms of flight hardware versus test hardware, location, and functions exercised shall be determined by the Contractor consistent with previously demonstrated performance.

4.5 Flight Proof Tests

Flight proof testing shall be conducted for each mission on flight hardware to demonstrate adequate workmanship. Component and system level testing shall be performed.

4.6 Integration Testing

Integration testing shall be performed with each payload to verify interfaces, demonstrate compatibility, and ensure compliance with the Interface Control Drawing (ICD).

5.0 NOTES

5.1 Verification (Paragraph 4.1)

5.1.1 Analysis

Verification by analysis is a process utilizing techniques and tools such as engineering analysis, statistics, computer and hardware simulations, analog modeling, validation of records, etc to verify requirements have been satisfied. It may be used in lieu of or in addition to testing when:

- Rigorous and accurate analysis is possible
- It is more cost effective than test
- Similarity is not applicable
- Inspection is not adequate

5.1.2 Similarity

Verification by similarity is permitted if it can be demonstrated that the article is sufficiently similar or identical in design to hardware that has been qualified to equivalent or more stringent environmental criteria.

5.1.3 Inspection

Verification by inspection may be used when visual examination of the hardware for compliance with workmanship, quality, and dimensional tolerance is sufficient. It may also include review of manufacturing records.

5.1.4 Demonstration

Verification by demonstration may be used when the qualitative determination of an article's properties can be made by observation under actual or simulated use conditions without special equipment or instrumentation.

5.1.5 Test

When an adequate level of confidence cannot be established by other methods of verification, testing shall be used. Testing employs technical means of measuring performance parameters relative to functional, electrical, mechanical, and environmental requirements.

5.2 Contamination Criteria (Paragraph 3.2.2.3.2)

5.1.1 Class 100,000

Class 100,000 is an index of measured particle size in microns, where 100,000 particles are allowed in a cubic foot of ambient environmental space. Particle size is limited to 0.5 microns or less, except 700 particles are permitted in the range from 0.5 to 5.0 microns.

5.1.2 Visibly Clean, Level II

Requires visual inspection from a distance of 2 to 4 feet with incident light of an intensity of 50 foot candles to verify the absence of all particulate and nonparticulate matter visible to the normal unaided eye. Particulate is identified as matter of miniature size with observable length, width, and thickness. Nonparticulate is film matter without definite dimensions.

APPENDIX A

ENHANCED CAPABILITY OPTIONS

This Appendix defines performance requirements for Enhanced capability Options to provide enhanced capabilities corresponding to CLIN __ in Section B.

A-1 Increased Payload Volume (Paragraph 3.2.2.1.1)

The Launch System shall accommodate payloads with a cylindrical envelope (including dynamic deflections and payload tolerances) 50 inches in diameter and 60 inches long.

A-2 Separation System (Paragraph 3.2.2.1.3)

The Launch System shall include a payload separation system that imparts a separation velocity of 3 ft/sec to the primary payload with tip-off rates less than 5 degrees per second. Constraints on payload characteristics to meet these requirements are TBS.

A-3 Insertion Accuracy (3-sigma) (Paragraph 3.1.2.2)

The Launch System shall provide a spacecraft orbit within $\pm$10 nmi in altitude and $\pm$0.1 deg inclination of the required orbit.

A-4 Conditioned Air (Paragraph 3.2.2.3.1)

The Launch System shall provide conditioned air to the payload at the launch pad. Temperature, humidity, and cleanliness shall be controlled.

A-5 Nitrogen Purge (Paragraph 3.2.2.3.2)

The Launch System shall provide a continuous clean dry nitrogen purge to the payload inside the fairing throughout processing up until launch.

A-6 Access Panel (Paragraph 3.2.2.1.2)

The Launch System shall provide a second access panel to the payload. Location shall be defined by the Government on a mission-by-mission basis.

A-7 Enhanced Telemetry (Paragraph 3.2.3.2)

The Launch Vehicle shall provide additional telemetry capability by increasing the total bit rate available to 2 Mbps.

A-8 Enhanced Contamination Control (Paragraph 3.2.2.3.2)

The Launch System shall include enhanced measures to minimize payload contamination:

(1) Use of out gassing materials, particularly on the payload fairing internal surfaces and other surfaces within the fairing shall comply with the following requirement: total mass loss (TML) of less than 1.0 percent and a collected volatile condensable mass (CVCM) of less than 0.1 percent when tested in accordance with ASTM E595. Materials that do not meet this requirement may be used if it can be shown that the effects on the payload are not significant compared to the total environment when using materials that meet the standard.

(2) Integration and testing shall be conducted in a Class 10,000 clean room or better environment, as defined in Federal Standard 209, in which the air shall have a maximum hydrocarbon content of 15 ppm or less. Humidity shall be maintained between 35 to 60 percent.

(3) After fairing installation, air supplied to the fairing volume shall have the quality equivalent to air filtered with a HEPA filter and shall have a maximum hydrocarbon content of 15 ppm. Humidity shall be maintained between 35 to 60 percent.

(4) Launch Vehicle surfaces interfacing with the payload envelope shall be cleaned to Visibly Clean Plus Ultraviolet cleanliness criteria defined as visibly clean when inspected:

(a) with normal vision 6-18 inches from the surface with 100 foot candle illuminance on the surface.

(b) with the surface illuminated by a black light (3200-3800 angstroms)

A-9 Launch Pad Environmental Control (Paragraph 3.1.2)

The Ground Segment shall provide environmental protection and access platforms to maintain the booster within required operating limits and support launch pad operations. Minuteman operating temperature limits are 60°F to 80°F.